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Synthesis of Silver Nanoparticles from Grewia Asiatica Plant and their Applications

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Article Details

ABSTRACT

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The production of plant-mediated nanoparticles is becoming more and more popular because it is economical and environmentally friendly. In this study, silver nanoparticles were produced using aqueous extracts of fresh *Grewia Asiatica* plant leaves as bio-reducing agents. This method made it possible to produce nanoparticles, which UV-visible spectrophotometry confirmed. After being treated with Ag precursors, the fresh leaf extracts' color changed to a brownish-yellow hue based on both visual examination and UV-visible spectra. Moreover, characterization is done using FTIR, SEM, and EDX. Additionally, the extract's ability to suppress biofilms and combat Gram-positive *Staphylococcus aureus* and Gram-negative *Escherichia coli* bacteria was assessed. The results showed that extracts containing AgNPs inhibited bacterial growth. To show the zones of inhibition that *Grewia asiatica* aqueous leaf extracts have against these bacteria, a statistical computation was conducted. TPC and TFC conducted the biological analysis of the plant extract and the nanoparticles that were produced from it; the greatest results were obtained for GA 0.5 and GA 0.3, respectively. The DPPH assay was used to assess their antioxidant capacity, and GA 0.5 had the highest value. AgNPs' ultrasensitive and selective optical response to Hg (II) causes a color shift from yellow to colorless. Spectroscopic analysis was used to conduct the test.

INTRODUCTION

Numerous laborers in the nanotechnology area guarantee that Richard Feynman, a physicist at California Institute of Technology, established the framework for nanotechnology in an after-supper discourse at the American Physical Society's Winter Meeting of the West in 1959 named, there is a lot of room at the base. Feynman is accepted to have explored the chance of controlling materials at the nuclear and atomic levels. The abilities of particle gathering and Nano engineering, as indicated by Feynman, could prompt new materials and pathways like the biological process [17]. He proposed nanotechnology, a logical concept of material scaling down, manipulation, and control on a limited scale. He predicted an innovation that fabricated Nano-objects molecule by molecule and atom by atom utilizing a natural toolbox [18]. The expression nanoscale, nanotechnology, Nano-engineering and Nano-object have turned into modern definitions of Feynman's. The terms used by Fenman are small size, small objects and miniaturization in his voice [7].

Nanotechnology is presently predicted to serve as the foundation for numerous biotechnology advancements in the twenty-first century, as well as the upcoming industrialization.

Nanoparticles are the wonders of contemporary medicine, so they have sparked a great deal of interest in recent decades [19]. This technology has currently used to create novel devices, materials, and systems at the atomic, Nano, and microscopic levels. Several government agencies in the U.S. Funds billions of dollars each year in nanotechnology. The National Science Foundation (NSF) is a prominent participant, sponsoring a large share of the research [20]. At the moment, the inventory compiled by Project on Emerging Nanotechnologies includes information on nanotechnology consumer goods that are already on the market.

Over 500 nanotechnology commercial goods are available for a broad range of purposes, with healthcare and exercising products being the most numerous. Home and garden are ranked second, followed by food and drinks. Cross-cutting, electronics, computers, machinery, automotive and children's products are other important categories. Cosmetics, clothing, athletic items, filtration, sunscreen, and personal care, are all subcategories of the health and fitness category. Among them, clothing and cosmetics are the most common sub-categories [5].

LITERATURE REVIEW

Chrysanthemum indicum had used to synthesize AgNPs, and the cytotoxic and antibacterial properties of AgNPs had investigated. The produced AgNPs are efficient bactericidal agents and have no harmful effects on mouse embryonic fibroblast cells [62].

It has been claimed that silver nanoparticles may be synthesized in one pot using *Terminalia arjuna* leaves extract. This simple, rapid, environmentally safe, cost-effective, and economical technology has effectively achieved AgNPs. The created nanoparticles demonstrated effective antibacterial properties and have the potential to be used in practical implants [63].

Moreover, The researchers established an eco-friendly and fast synthesis of high purity silver NPs using sodium alginate at various concentrations of NaOH for acceleration of reaction. A reduced quantity of NaOH resulted in the creation of nameplates, whereas an increase in NaOH concentration resulted in the development of Nano spheres. The presence of functionality group of sodium alginate as a stabilizing and reducing agent was used to control nanoparticle aggregation. The newly synthesized nanoparticles could have a wide range of uses in the chemical, food, and pharmaceutical industries [64].

Silver nanoparticles were synthesized from the seeds extract of *Nyctanthes arbor-tristis* with silver nitrate solution by heating at 25°C for 20 minutes. These may be employed for biomedical and catalytic applications [65].

Dendropanax morbifera Leveille is an oriental pharmaceutical plant that grows in a particular location of South Korea and is extensively utilized in medicinal properties. The researchers wanted to improve the use of *D. morbifera* herbal medicines by preparing their silver and gold nanomaterials. *Dendropanax* silver and gold nanomaterials were speedily produced using the extract from these plants as both a stabilizing and a reducing agent. Because of its deficiency of normal cell cytotoxic effects, D-AuNPs can be employed as a drug carrier and in the treatment of cancer [66].

Furthermore, The authors present a high-quality approach for one-pot amalgamation of AgNPs employing onion extracts as a reducing and stabilizing agent. Square wave voltammetry was used to analyze the influence of produced nanoparticles on vitamin C concentration. The peak intensity of vitamin C square wave voltammograms rose proportionally with detection limit of 0.4–450.0 micro molar. Vitamin C has a limit of detection of 0.1 micromolar [67].

The pine (*Prunus persica*) species needle extract was used in a green process for silver nanoparticles synthesis. This study demonstrated the capacity for heavy metal removal from wastewater, such as Pd and Cd, by investigating the catalytic activities of bio-produced AgNPs. When contrast to Pd, Ag nanomaterials shown greater catalytic efficiency against Cd heavy metals. The area for future work is the creation of a constant method for heavy metal removal and the exploration of biological characteristics for the manufacturing of bio sensing materials utilizing these nanomaterials and their implementation in pharmaceuticals via organic media

[68].

A method for the synthesis of silver nanomaterials that is fast, cost-effective, and environmentally friendly was created by employing a root extract of *Glycyrrhiza glabra* as a reductant and a household microwave as a reaction booster. The nanomaterials demonstrated the viability of treating oral disorders. Their antibacterial activity towards *Streptococcus mutans* was demonstrated by bactericidal concentrations and minimal inhibitory of 25 and 6.25 g/ml, correspondingly. They were hazardous to tumor types (HN-30) but not to human periodontal tissues. The anti-oxidative activity was also detected, implying that it could be used in therapeutic diagnostics [69].

The researchers prepared silver nanoparticles from the leaves and roots of *Berberis vulgaris*. The Minimum Inhibitory Concentration and disk diffusion testing were used to determine the antimicrobial impact of these nanoparticles on *Staphylococcus aureus* and *Escherichia coli* bacteria [70].

Lastly the extract of the seed of *J. curcas* was used to create Ag nanoparticles in a greenway. The majority of particles are globular. By adjusting the concentration of AgNO₃, the size of the particles can be adjusted. This method produces silver nanoparticles that are quite stable, it can last nearly two months. If provided protection under light-proof situations [71].

RESEARCH METHODOLOGY

CHEMICALS AND MATERIALS

All of the chemicals used in the research were of analytical quality. Leaves of *Grewia asiatica* (plant) were collected in May, as this species flourishes in a hot climate. It was identified by MS. Amber Raza, Botany Department, of Government Sadiq College Women University, Bahawalpur.

INSTRUMENTS AND EQUIPMENT'S

The instrument and equipment are, Digital Electronic balance (Shimadzu, Model AUW220D, Japan). Centrifugation machine (Labnet), Rotary evaporator (Helidoph), Water bath (Mettler), Micropipette (Gilson), UV Visible Spectrophotometer (Agilent Cary 60), Fourier Transform infrared spectroscopy (Burker Ten sor 27), Scanning electron microscopy (Nova Nano SEM 450), were used during the present work.

PURIFICATION OF SILVER NANOPARTICLES

0.3Mm, 0.5mM, 0.7mM, 0.9Mm AgNPs from the solution were purified by firstly concentrated in a rotary evaporator. Then washed them with distilled water to remove any impurity if it was present. After this, dried them on a hot plate at 60-70°C as shown in figure 5. Finally, the completely dried powder was packed in sample vials.



FIGURE 1: DRIED SILVER NANOPARTICLES

CHARACTERIZATION OF SILVER NANOPARTICLES

UV-visible spectrometer was used for measuring and detection of the bio reduction of Ag⁺ ions to AgNPs in solution. FTIR spectrophotometer, SEM, EDX, and XRD are for further analysis [97, 98]

1. UV-VISIBLE SPECTROMETRY

Spectrometry is a strategy involving the association of particles with the electromagnetic spectrum. when the electrons in particles absorb specific energy in the UV and visible regions, they are excited from a lower energy state to a higher one. In order to produce a spectrum, it is necessary to quantify the absorption of light in relation to its wavelength [99].

In the conduction band, metal surfaces have protons and unbound electrons. The excitation of the electrons in the conduction band; near the external layer of the nanomaterials occurs. Electron is confined to vibrate at specific frequencies by the particle's shape and size. Thus, nanoparticles made from metals have unique absorbance ranges [100]. It is one of the most broadly utilized strategies for the characterization of silver nanoparticles. It uncovered the arrangement of AgNPs by exhibiting the characteristic surface plasmon absorbance maximum at 418-420 nanometer from the UV-Vis range [101]. Silver nanostructures show intriguing optical properties identified with surface plasmon resonance (SPR) that heavily rely upon the morphology of the samples. UV-Visible retention spectrophotometer uses for the examination of the SPR [102].

The bio reduction of silver ions to silver nanoparticles takes place by using the leaf extract of *Grewia asiatica*. A color change initially confirmed their production, and a UV-Visible spectrophotometer was used for further characterization.

2. FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

FTIR spectroscopy is very easy, reproducible, nondestructive to the tissue, and only requires a

tiny amount of material with minimal preparation of the sample. These approaches provide molecular-level information, allowing the analysis of bonding types, molecular functional groups, and conformations of molecules. Unearthly groups in vibrational spectra are atom explicit and give direct data about the biochemical piece. These groups are moderately thin, simple to determine, and delicate to atomic design, adaptation, and climate. [103].

Various kinds of sub-atomic bonds use to distinguish rotation and vibration modes in a given substance. The energy related to these modes is measured. A greater level obtains if an amount of energy precisely equivalent to the contrast between two energy levels transmits to the atom. As the photon's energy is parallel to the absorbance of the radiation and the Planck's constant, a given kind of bond can arrive at a higher actuation level by retaining a quantum comparing precisely to a particular infrared (IR) recurrence [104].

The principle of the FTIR method depends on the atoms or their groups that vibrate at finely characterized frequencies thus, being effective for measuring the chemical composition of a compound. The IR frequencies contain the changes between vibrational energy states for particular bonds and vibrational types and lie in the infrared electromagnetic range. There are specific frequencies that molecules assimilate if put in an infrared beam and send all other frequencies [105].

For metallic nanoparticles, FTIR spectroscopy is being used to identify components that react with the particles' surfaces [106].

3. TOTAL FLAVONOID CONTENT ESTIMATION (TFC)

TFC was evaluated by using the colorimetric technique. 2 mL of the AgNPs was combined with 2 mL of a 2 percent Aluminum chloride hexahydrate solution and incubated at room temperature for 5 minutes. The samples' absorbance was measured at 420 nm using distilled water as a blank, and the findings were reported as Gallic acid equivalents.

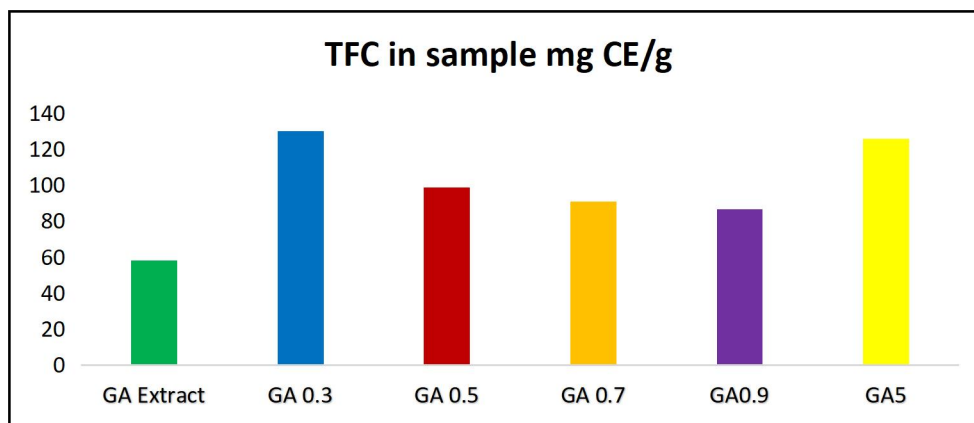


FIGURE 2: TOTAL FLAVONOIDS CONTENT IN AGNPS

ANTIOXIDANT ACTIVITY ASSESSMENT

Phenols are those compounds generated in every species of plant that functions mainly as antioxidants by acting as reductants [111]. The ethanolic leaf extract of *Grewia asiatica* contains flavonoids, sterols, tannins, and saponins [30]. The main antioxidant activity is attributed to the flavonoids isoflavones, flavones, anthocyanins, and isocatechins found in this species of *Grewia* [118].

1. DETERMINATION OF DPPH ACTIVITY

Because of the availability of bioactive compounds on the surface of AgNPs, they exhibit significant antioxidant activity [119]. DPPH is an oxidant that is persistent at ambient temp. Its solution is purplish, but antioxidants reduce it, and the solution becomes colorless. It allows for a simple and quick evaluation of antioxidant properties [120]. The antioxidants' electron-donating capability to the nitrogen of the DPPH is used to evaluate the DPPH radical scavenging activity [121].

Overall, the analysis shows that all samples could remove free radicals, and GA 0.5 had a high capacity for free radical scavenging activity. It might attribute to the abundance of electron-donating groups (carboxyl and hydroxyl) on the surface. The nanoparticles of silver (0.5mM) had a better percent DPPH scavenging activity than the other concentrations in the subsequent sequence:

GA 0.5 > GA 0.9 > GA5 > GA0.3 > GA0.7 > GA extract as shown in figure 3.

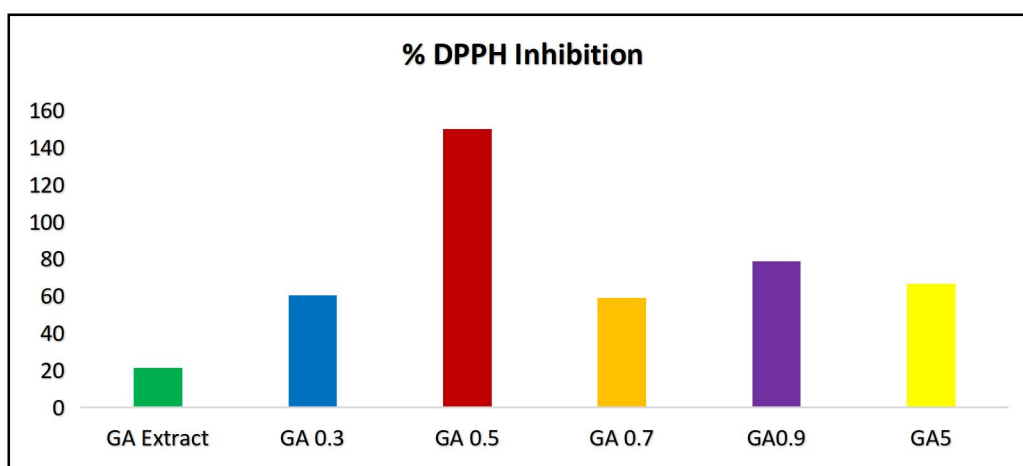


FIGURE 3: DPPH ACTIVITY OF AGNPS

2. ANTIBACTERIAL ACTIVITY

The five specimens of silver nanoparticles were exposed to antibacterial action against two bacterial strains utilizing ciprofloxacin as a reference standard. Against both gram-positive and gram-negative microscopic organisms, *S. aureus* and *E. coli*, the specimen GA 5 stayed the most

effective. GA 0.9 and GA 0.7 specimens remained reasonably and equally active. GA 0.5 and GA 0.3 specimens were the less effective antibacterial agents than other samples. It indicates that as the size of the particles increases, so as the antibacterial activity increases, as shown:



FIGURE 4: ANTIBACTERIAL EFFECT OF AGNPS

The inhibition zone was noted for every mixture and is recorded in Table-1 and graphically in Figure-4

TABLE 1. ANTIBACTERIAL ACTIVITY OF AGNPS BY GREWIA ASIATICA

SR #	Samples	<i>Staph aureus</i> (ZOI)	<i>E. Coli</i> (ZOI)
1	GA Extract	4	6
2	GA 0.3	5	8
3	GA 0.5	7	8
4	GA 0.7	9	9
5	GA 0.9	9	9
6	GA 05	10	9
7	Ciprofloxacin (STD)	27	25

ANTIBACTERIAL EFFECT OF AGNPS

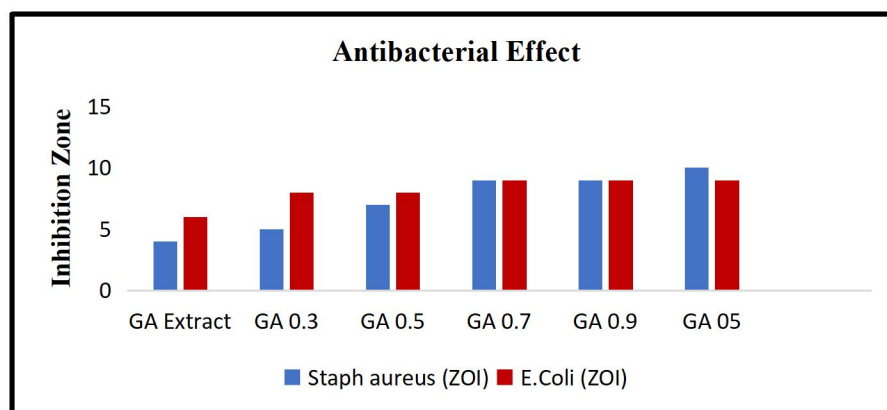


FIGURE 5: ANTIBACTERIAL EFFECT OF AGNPS

BIOFILM INHIBITION ANALYSIS

Silver nanoparticles were utilized to inhibit biofilm activity. Their potential to suppress the biofilm activity produced by the microorganisms *E. Coli* and *S. aureus* were evaluated in the present thesis. The strains were cultivated in microtiter plate wells for a day before being treated with silver nanoparticles. The biologically produced nanoparticles reduced the biofilm activity in both bacterial strains as shown in graph.

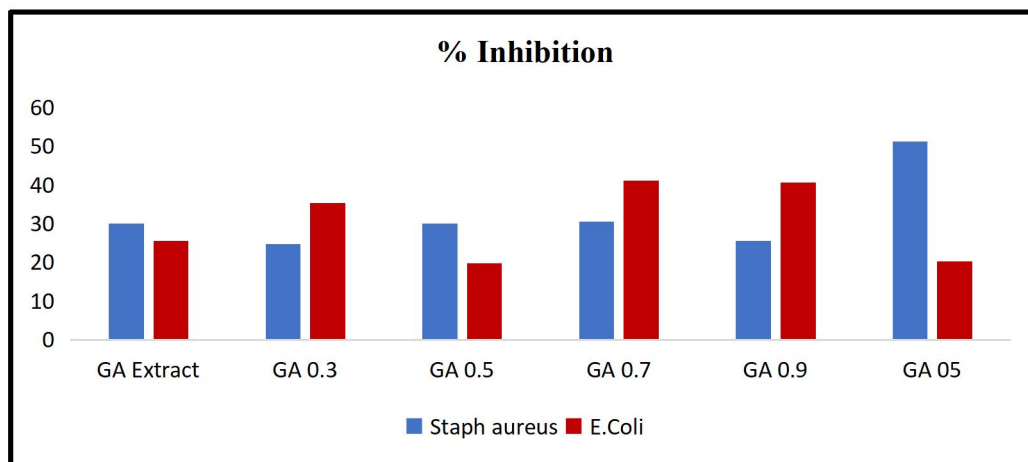


FIGURE 6: % INHIBITION OF AGNPS

DETECTION OF METAL ION IN WATER SAMPLES

The release of heavy metals, particularly mercury, into the environment is a significant global concern because of various harmful repercussions. It is soluble in water due to this; it is one of the most common and stable forms of inorganic mercury that is present generally in the water. It can cause health issues in the kidneys, brain, and neurological system. So, it is essential to measure Hg (II) concentrations in aqueous conditions with high sensitivity.

The UV-VIS spectrum of silver nanoparticles solution after adding Hg⁺² and Pb⁺² was shown in Fig.17. In the absence of Hg⁺² and Pb⁺², a distinctive SPR band at 420 nm was observed. The absorption peak at 420 nm disappears with the addition of Hg²⁺ and Pb²⁺.

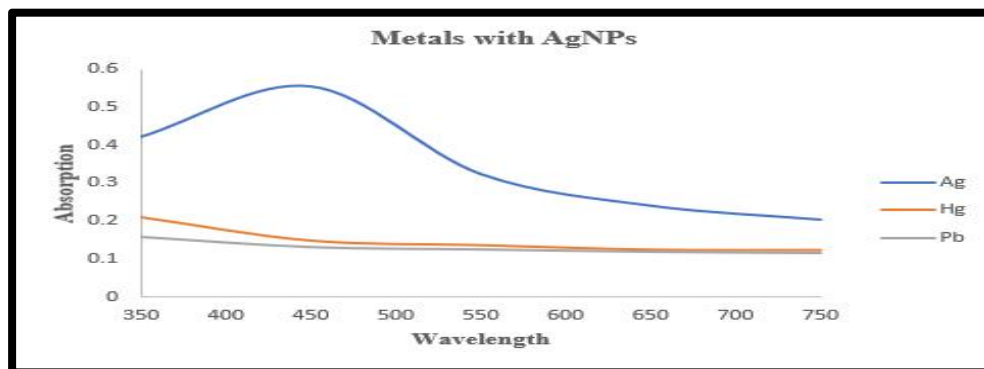


FIGURE 7: METAL INTERACTION WITH AGNPS

CONCLUSION

For nanotechnology to advance, an effective and ecologically friendly method for producing metallic nanoparticles must be established. In nanotechnology, nanomaterials are thought to be crucial building blocks. AgNPs are important in treatments because of their desirable physiochemical characteristics. In this work, silver nanoparticles are synthesized without the use of hazardous chemicals or waste by using *Grewia asiatica* leaf extract, an organic, inexpensive biological reducing agent. The disc diffusion method is used to determine the antibacterial activity of AgNPs from *Grewia asiatica*, and it shows that the results for *E. coli* and *Staphylococcus aureus* are similar.

AgNPs can now be produced quickly and affordably thanks to the current work. The ability to be used by companies that produce nanomaterials is an additional advantage of *Grewia asiatica*. In the presence of produced AgNPs, biofilm development was effectively suppressed. The antibiofilm mode of action of silver nanoparticles is explained by Ag ions' capacity to penetrate the bacterial biofilm matrix. It demonstrates how AgNPs can combat bacterial infections by upsetting biofilms, and they can be applied to diabetic foot ulcers and skin conditions. The nanomaterials' antioxidant activity was discovered, suggesting their potential applications in the medical field and as treatment agents for a range of oxidative stress-related illnesses. The findings demonstrated that, in comparison to other concentrations, AgNPs with a GA 0.5 concentration had a larger TPC. As a result, this concentration also has stronger antioxidant action. The generated nanomaterials were found to be both sensitive and selective for Hg²⁺ ions when employed for colorimetric detection of Hg²⁺ ions in water.

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